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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

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First Named Inventor or Application Identifier	J. Sturges
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APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] *Fee Transmittal Form (e.g. PTO/SB/17) (Submit an original, and a duplicate for fee processing)
2. [X] Specification — Total Pages [33] (preferred arrangement set forth below)
   - Descriptive Title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R&D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claims
   - Abstract of the Disclosure
3. [X] Drawing(s) (35 USC 113) — Total Sheets [10]
4. [X] Oath of Declaration — Total Pages [2]
   - a. [ ] Newly executed (original copy)
   - b. [X] Copy from prior application (37 CFR 1.63(d)) (for continuation/divisional with Box 17 completed)
   - i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in prior application, see 37 CFR 1.63(d)(2) and 1.33 (b).

* Note for Items 1 & 13: In order to be entitled to pay small entity fees, a small entity statement is required (37 CFR §1.27), except if one filed in a prior application is relied upon (37 CFR §1.28)

5. [ ] Microfiche Computer Program (Appendix)
6. [ ] Nucleotide &/or Amino Acid Sequence Submission (if applicable, all necessary)
   - a. [ ] Computer Readable Copy
   - b. [ ] Paper Copy (identical to computer copy)
   - c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 CFR3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
9. [ ] English Translation Document (if applicable)
10. [X] Information Disclosure Statement (IDS)/PTO-1449 [—] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503)
13. [ ] *Small Entity Statement(s) [ ] Statement filed in prior app Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
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16. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information below & in a preliminary amendment:
[X] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application no: 08/287,064

Prior application information: Examiner: P. Kulik Group/Art Unit: 2307

For Continuation or Divisional Apps only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

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PATENT
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UNITED STATES PATENT APPLICATION

for

PROGRAMMABLE INTERPRETIVE VIRTUAL MACHINE

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FIELD OF THE INVENTION

The field of the invention relates to the field of computer programming languages. Specifically, the field of the invention is that of creating, interpreting, and executing a computer programming language.

BACKGROUND OF THE INVENTION

The current common method for interpreting a computer programming language and processing of same, is to transpose the highest level form into a more generic form of pseudo language. Typically, the programming language is transposed into an assembly language. This pseudo language is then interpreted and processed via branch to appropriate functions and procedures.

This process of transposing a programming language into a pseudo language before execution is a time consuming step. Typically the time required to transpose high level code into pseudo code can be equal to if not longer in time than processing the pseudo instruction set.

Additionally, transposing and executing the originally specified logic in pseudo code form typically creates a performance loss in the operation of the logic. With transformation into a new form, there is a loss of expression which must be realized in the new form. This loss is reflected in repetitions of instructions. For example, a conditional statement of a computer programming language may be realized in the following form:

```
while (j < 10) do
        begin
                j : = j + 1
        end
```

In the typical prior art method of interpreting a programming language, the above example would typically be transposed into a test condition statement with label, an arithmetic expression, an assignment statement and jump to the test condition statement label. Given that the arithmetic expression would be equivalent to one instruction, this prior art transposition would produce at least five pseudo code instructions. These

five pseudo code instructions would then be executed sequentially in at least five processor clock cycles. Thus, relatively simple expressions in a high level language may result in the execution of many pseudo code instructions.

The step of transposing a programming language into a lower level code form prior to execution may cause the loss of the essence of the initial expression. Depending upon the effectiveness of the transposing process (i.e. compiler or interpreter), errors may be introduced for particular code constructions. The level and severity of errors introduced in this manner affects the reliability and reusability of the software being interpreted. Additionally, the transposing step consumes processor time and therefore degrades performance of the interpreter system.

It is therefore an objective of the present invention to provide a method and a means for eliminating the intermediate step of transposing a programming language into a lower level code form prior to execution. It is a further objective of the present invention to provide an improved method for creating, interpreting, and executing an interpretive programming language. It is a further objective of the present invention to provide a means and method for improving the performance of an interpreter system. It is a further objective of the present invention to provide a means and method for improving the reliability of the results produced by an interpreter system.

SUMMARY OF THE INVENTION

The present invention provides a means and method for creating, interpreting, and executing a programming language. The present invention is a virtual processor that eliminates interpretation of pseudo code typical of common interpretive engines. By removing this step, the loss of the essence of the initial expression will not occur.

The preferred embodiment of the present invention includes a computer system comprising a bus communicating information, a processor, and a random access memory for storing information and instructions for the processor. The processing logic of the preferred embodiment is operably disposed within the random access memory and executed by the processor of the computer system.

A command stream is a typical input for the processing logic of the present invention. A command stream in this form may be produced by operator entry of an alphanumeric string on alphanumeric input device, included as a command line in a previously generated file and stored on read only memory device, or produced by a parser or preprocessor that outputs a command stream. The syntax of such a command stream consists of a command identifier or function name in combination with a string of arguments or parameters associated with the operation of the identified command.

Upon activation of the processing logic of the present invention, a Reset subroutine is executed to initialize pointers into the command stream and stack and frame pointers. A parser is then executed to manipulate the input command stream and produce an execution stream. The parser includes a call to a function that sets up pointers into the execution stream and produces a subroutine address (i.e. a processing component identifier) corresponding to the specified command. The command is then executed indirectly and a pointer is updated to point to the next command in the execution stream. Arguments for commands are pushed on to and popped from the execution stream using a stack pointer. Results from the execution of commands are pushed onto the stack. For commands that define a new function or procedure, frame data is

maintained to preserve the context in which the new function or procedure is executed. Each command in the execution stream is interpreted in this manner until the end of the execution stream is reached.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of the typical prior art computer system bus architecture.

Figure 2a illustrates a typical example of a command stream input to the processing logic of the present invention.

Figure 2b illustrates a typical example of an execution stream input to the processing logic of the present invention.

Figures 3a, 3b, 4a, 4b, 5a, 5b, 6a-c, 7, and 8a-d depict the execution flow of the processing logic of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a means and method for creating, interpreting, and executing a programming language. Such programming languages include algorithmic languages, logic and control structures, processing structures and virtual processor means for solving problems. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be apparent to one with ordinary skill in the art that these specific details need not be used to practice the present invention. In other instances, well-known logic structures, data structures, and interfaces have not been shown in detail in order not to unnecessarily obscure the present invention.

The present invention provides a general high performance means to interface a programming language to software applications. The present invention is a virtual processor designed to remove interpretation of pseudo code typical of common interpretive engines. By removing this step, the loss of the essence of the initial expression will not occur; thus, a

lower level of detailed knowledge is not required by the interpreter. Taking the earlier example of a conditional looping statement:

```
while (j < 10) do
    begin
        j : = j + 1
    end
```

The above statements are executed by the present invention as a generic 'while' statement offered within a programming language, an arithmetic expression, and an assignment. Given that the arithmetic expression would be equivalent to one instruction, this form is equivalent to three pseudo code instructions. By providing the expression of the original statement, the interpretive engine can execute the task in a more efficient duty cycle.

The advantages of this new method over the traditional is in the area of performance. By driving directly to the actual object code of the executing program rather than generating an intermediate pseudo code form, typical pre-compilation steps are not required. Additionally, by interpreting the actual expression as presented, a more cost effective duty cycle is achieved as measured in time.

The present invention includes a method by which capture and execution of the programming language is performed. Additionally, further advantages are gained in the manner in which the data is stored with relevant data structures and relationships between data items are maintained.

With the advent of high performance hardware computer systems one may realize the value of utilizing programming engines to more generalize software systems. This allows for higher reusability of software during a software systems lifecycle. Additionally, it has been realized via prototype that with the form of interpreting and executing commands in the present invention, one can expect a 2 to 4 times increase in performance over traditional methods of interpretation.

The preferred embodiment of the present invention is implemented on a Sun Microsystems, Inc. brand computer system. Other embodiments are implemented on IBM PC brand personal computers and other computer systems. It will be apparent to those with ordinary skill in the art, however, that alternative computer systems may be employed. In general, such computer systems, as illustrated by Figure 1, comprises a bus 100 for communicating information, a processor 101 coupled with the bus for processing information, and a random access memory 102 coupled with the bus 100 for storing information and instructions for the processor 101. Optionally, such a computer system may include a display device 105 coupled to the bus 100 for displaying information to a computer user, a read only memory 103 coupled with the bus 100 for storing static information and instructions for the processor 101, a data storage device 113 such as a magnetic disk and disk drive coupled with the bus 100 for storing information and instructions, and an alphanumeric input device 106 including alphanumeric and function keys coupled to the bus 100 for communicating information and command selections to the processor 101.

OPERATION OF THE PREFERRED EMBODIMENT

The processing logic of the preferred embodiment is operably disposed within random access memory 102 and, executed by processor 101 of the computer system described above. The processing logic of the present invention may equivalently be disposed in read-only memory 103 or other memory means accessible to processor 101 for execution. A means for loading and activating the processing logic of the present invention exists using techniques well known to those of ordinary skill in the art. Once activated, the processing logic of the present invention operates in the manner described below.

Listing A, provided herein, presents the Baucus Naur description of the supporting data structures and relationships used in the present invention. A detailed specification of the processing logic of the present invention is provided herein in Listing B. Both Listing A and Listing B are provided at the end of this detailed description, but before the claims.

Referring now to the example illustrated in Figure 2a, a typical command stream 21 input to the processing logic of the present invention is illustrated. Such a command stream is typical of the input received by the interpreter of the present invention; however, the techniques of the present invention are not limited to manipulation of input in the particular form illustrated in Figure 2a. Rather, Figure 2a is intended only as a specific example of a typical command stream input.

A command stream 21 in the form of Figure 2a may be produced by operator entry of an alphanumeric string on alphanumeric input device 106, included as a command line in a previously generated file and stored on read only memory device 103, or produced by a parser or preprocessor that outputs a command stream 21 in the form as shown in Figure 2a. The syntax of such a command stream 21 consists of a command identifier or function name in combination with a string of arguments or parameters associated with the operation of the identified command. Such a command stream may be stored in sequential locations of random access memory 102.

Referring still to Figure 2a, an example of an addition function command stream 21 is illustrated. In this addition function example, a command identifier, or plus sign (+) in this case, is stored in a second memory location 32. Arguments for the addition operation are stored in a first memory location 31 and a third memory location 33. The first memory location 31 corresponds to a first argument (in this example, a constant value of 6) for the addition operation. The third memory location 33 corresponds to a second argument (a constant value of 5) for the addition operation. Other commands and arguments in the command stream may be stored in subsequent memory locations 34 in the command stream 21.

In a manner described below, the command stream 28 is translated into an execution stream 28 as shown in Figure 2b. Pointers are used to reference locations within execution stream 28. The use of pointers in this way is a technique well known to those or ordinary skill in the art. A base code pointer 22, denoted BCODE, is used by the present invention to identify an initial position of a command within execution stream 28. Another pointer 23, denoted PCODE, is used to identify the first location of a subsequent command in execution stream 28. Pointer 23 thus implicitly identifies the end of a command identified by pointer 22. Initially, PCODE points to the same location as BCODE. The manipulation and control of these and other pointers will become apparent in the detailed description of the processing logic of the present invention presented below.

The flow charts of Figures 3a, 3b, 4a, 4b, 5a, 5b, 6a-c, 7, 8a-d are used to best illustrate the processing logic of the present invention. Listing A and Listing B provide an additional detailed description of the preferred embodiment of the present invention. Once activated in a manner well known in the art, the processing logic of the preferred embodiment starts at the block labeled Program Start 101 as illustrated in Figure 3a. First, a procedure is called to initialize the pointers used by the present invention. In the preferred embodiment, a call 102 is made to a subroutine denoted RESETPC as illustrated in Figure 3b.

Referring now to Figure 3b, the RESETPC subroutine is illustrated. As indicated, the RESETPC subroutine is called with an input parameter identifying the base code pointer contents (BCODE). As described above and illustrated in Figure 2b, the base code pointer points to the first location of a command within execution stream 28. Referring still to Figure 3b, the base code pointer BCODE is used to initialize another pointer denoted PCODE (processing block 112). The PCODE pointer is used to point to the next command following the command to which BCODE points. In processing block 113, a stack pointer, denoted STACKP, is initialized to the top of a stack located in random access memory. The stack pointer is used by the present invention for pushing and popping arguments for commands in the execution stream 28. In processing block 114, a frame pointer, denoted FRAMEP, is initialized to the top of a frame also stored in random access memory. A frame is a collection of information that fully defines a context in which a newly defined function operates. The frame pointer is used for storing and accessing frame information when a new function is defined or executed in an execution stream. Once these pointers are initialized, processing control returns from the RESETPC subroutine via a return call (processing block 121).

Referring again to the logic illustrated in Figure 3a, processing continues at decision block 103. The present invention includes a parser for converting the raw command input of Figure 2a into a form similar to that illustrated in Figure 2b and described above. As an intermediate step, the parser produces an execution stream by pushing the arguments of the input command into the execution stream in reverse order. The stack pointer is used for the push operation. Functions associated with each argument are also pushed onto the stack in order to identify the data type of the arguments. Thus, for the sample raw input command (6 + 5), an intermediate execution stream is created in the following form: <constant push> <5> <constant push> <6> <add>. This intermediate stream is then processed by the parser into the execution stream shown in Figure 2b.

Upon activation of the parser in decision block 103, the processing logic for the parser is executed as illustrated in Figure 4a. Referring to Figure 4a, raw command input is parsed in processing block 200 using a call to an ENCODE_STATEMENT function as illustrated in Figure 4b. Referring now to Figure 4b, the ENCODE_STATEMENT processing logic begins by setting an OPCODE pointer to the pointer value contained in the PCODE pointer (processing block 201). Initially, the PCODE pointer points to the same location as the BCODE pointer as initialized by the RESETPC procedure described above. The PCODE pointer, and thus the OPCODE pointer after the assignment statement of processing block 201, point to the first item in the command stream 21. This item corresponds to the number six (6) which is the first argument in the addition example and located in memory location 31 of the example in Figure 2a. The first argument is used in processing block 202 in a call to the FUNCTION subroutine illustrated in Figure 7.

Referring now to Figure 7, the processing logic for the FUNCTION subroutine is illustrated. The FUNCTION subroutine accepts as input an argument and returns the address of a function or procedure (i.e. a processing component identifier) used to process the associated argument. For example, if the input argument is a number, as is the case with the argument six (6), the FUNCTION subroutine returns the Constant Push (CONST PUSH) function in processing block 528. Similarly, the addresses of other subroutines (i.e. processing component identifiers) are returned for arguments or command identifiers associated with them in each of the other processing blocks in the FUNCTION subroutine illustrated in Figure 7. For example, if the command identifier present in the execution stream is the plus sign (+) or an addition operator, the FUNCTION subroutine returns the address of an add subroutine as illustrated in processing block 500. The returned functions and arguments are pushed onto the execution stream using the stack pointer.

Referring again to Figure 4b, the processing component identifier associated with the command identifier present in the command steam 21

is returned to the invocation in processing block 202. This processing component identifier is stored into the execution stream 28 at the position to which the PCODE pointer currently points (i.e. location 43). The PCODE pointer is then bumped to the location of the next command identifier in the execution stream, if one is present as shown in Figure 2b. The PCODE pointer is bumped to the next command identifier location by computing the length of the command returned by the FUNCTION subroutine invocation in processing block 202. Since each of the functions returned by the FUNCTION subroutine in processing block 202 has a determinable length, the quantity of memory locations consumed by each command can be predetermined. A function called SIZEOF is used to compute the number of memory locations consumed by each command. Thus, as illustrated in Figure 5b, on invocation of the SIZEOF function 320, the memory storage size is returned in processing block 321.

Referring again to Figure 4b, the size of the current command is added to the contents of the PCODE pointer thus bumping the PCODE pointer to the next command identifier location in the execution stream (processing block 203). The processing for the ENCODE_STATEMENT subroutine then terminates at the return statement 221 where the OPCODE pointer is returned. Processing for parser 210 as illustrated in Figure 4a then terminates at processing block 211. Having completed parser processing, control returns to decision block 103 as illustrated in Figure 3a.

At the completion of parser processing, the execution stream 28 appears as shown in Figure 2b for the addition command example illustrated above. As shown in Figure 2b, the PCODE pointer 23 has been bumped to a position one memory location greater than the end of the ADD command and its associated arguments. Moreover, the address of the ADD function (i.e. the processing component identifier) has been stored at memory location 43.

Referring again to Figure 3a, if the result produced by the parser subroutine invocation at decision block 103 produces a null execution stream, processing path 108 is taken to processing block 104 where the

processing logic of the present invention terminates for the null execution stream. If, however, the execution stream 28 produced by the parser is not null or empty, processing path 109 is taken to decision block 105. At decision block 105, an INTERPRET subroutine is invoked to interpret the commands in execution stream 28. The processing logic for the INTERPRET subroutine is illustrated in Figure 5a.

Referring now to Figure 5a, a parsed execution stream is interpreted and the commands therein are executed. First, the BCODE pointer is used to initialize a PC pointer (processing block 300). Beginning at decision block 301, a loop is initiated for executing the commands within execution stream 28. First, a test is made to determine if the PC pointer is pointing to a null or empty item. If so, processing path 305 is taken to processing block 302 where a return statement is executed thereby terminating the interpretation of execution stream 28. If, however, the PC pointer is not pointing to a null item, processing path 306 is taken to decision block 303. At decision block 303, the processing component identifier to which the PC pointer is pointing is accessed and the function or procedure addressed thereby is invoked. Again using the add function command example described above and illustrated in Figures 2a and 2b, the Add function is indirectly invoked at decision block 303. The processing logic thus initiated is illustrated in Figure 8c.

Referring now to Figure 8c, the processing logic for the Add function example is illustrated. Upon invocation, the Add function first retrieves the two operands for the add operation. The two operands are retrieved from the execution stream 28 stack using the POP function and the associated stack pointer. The first operand thus retrieved (processing block 610) is stored in a data item identified as D2, since this operand is the last operand pushed onto the stack. The second operand retrieved (processing block 611) is similarly stored in a data item denoted D1, since this item is actually the first operand pushed onto the stack.

Referring now to Figure 6a, the processing logic for the POP function is illustrated. On invocation of the POP function, the stack pointer is bumped to point to the last item pushed onto the stack (processing

block 400). Next, the memory address of the stack pointer is returned in processing block 401 using the logic illustrated in Figure 6c. By returning the memory address of the stack pointer to the subroutine invoking the POP function, the address of the last item pushed onto the stack is provided to the calling function.

Referring again to Figure 8c and the Add operation example, processing block 612 is executed to add the contents of the two operands retrieved from the stack. The resultant sum is stored in a location denoted D1. The PUSH function is thereafter invoked to push the resultant sum onto the execution stream 28 stack (processing block 613). The processing logic for the PUSH function is illustrated in Figure 6b.

Referring now to Figure 6b, the processing logic for the PUSH function is illustrated. On invocation, the stack pointer is bumped to point to the next available location in the stack (processing block 402). Next, the data item to be pushed onto the stack is stored in the location to which stack pointer is pointing (processing block 403). The PUSH function then returns the memory address of the stack pointer (processing block 404) using the processing logic illustrated in Figure 6c.

Referring again to Figure 8c, processing for the Add function example is completed by the execution of the return statement 641.

Having completed execution for the Add function, processing control returns to decision block 303 illustrated in Figure 5a where the Add function is originally indirectly invoked. It will be apparent to those skilled in the art that any of the functions illustrated in Figure 7 or other functions readily available may be invoked using the logic structure illustrated in Figure 5a. In each case, the execution stream 28 stack is used as the source for input parameters for functions as well as the destination for the results produced by the invocation of a function. In a similar manner, for example, a subtract function may be invoked at decision block 303. Processing logic for a subtract function is illustrated in Figure 8d.

One capability supported by the processing logic of the present invention includes defining and executing new procedures and functions.

Referring again to Figure 7, the definition of a new procedure is provided by processing block 514. Similarly, a function definition is provided by processing block 527. In both cases, the address of the new procedure or function is returned as a pointer. Having been defined, new procedures and functions may be executed using processing block 529 and processing block 530 also shown in Figure 7. In each case, an EXEC function address (i.e. a processing component identifier) is returned and stored in the execution stream 28. The processing logic for the EXEC is illustrated in Figure 8b and described below.

Finally, a return function is provided at processing block 526 as illustrated in Figure 7. The return function provides a means for returning control from either the execution of a procedure or a function. The processing logic for the return function is illustrated in Figure 8a.

Referring now to Figure 8b, the processing logic for the execute command (EXEC) is illustrated. On invocation of the EXEC command (processing block 660) a single argument is passed as input. This single argument is a pointer to a subroutine or function to which execution control should be passed. If this pointer points to a subroutine, processing path 609 is taken to processing box 606 where the subroutine is activated using a PCALL function. Upon completion of the execution of the subroutine, the return statement 661 is executed thereby terminating the execute command. If, however, the input pointer to the EXEC command is not a subroutine, processing path 608 to processing block 606 where a function is called. Upon completion of the function call, the return statement 662 is executed thereby completing execution of the EXEC command.

Referring now to Figure 8a, the processing logic for the return command (RET) is illustrated. Again, a single input parameter identifies whether the return command is being used in conjunction with a function return or a procedure return. If the input parameter identifies a function return, processing path 604 is taken to processing block 602 where a function return statement is executed. If, however, a procedure return is specified by the input parameter (processing path 603), processing block

601 is executed thereby initiating the return from a procedure. Processing for the return command terminates with the return statement 631 illustrated in Figure 8a.

Thus, an efficient means and method for creating, interpreting, and executing a programming language is disclosed.

Although this invention has been shown in relation to a particular embodiment, it should not be considered so limited. Rather, it is limited only by the appended claims.

LISTING A

Baucus Naur Form Description Conventions:

```
::=             definition
'. . .  '       literals
< . . .  >      nonterminals
[ . . .  ]      optional
( . . .  )      grouping
{ . . . }       repeat 0 or more times
. . . | . . .        choice (or)
:m:n            repeat m to n times
ASCII           The ASCII character Set
NIL             The empty set
EOL             The end of line marker
```

```
engn            ::=      NIL
                     |   { EOL }
                     |   { <statement> }

statement       ::=      'exit'
                     |   'do' [ <statement> ]
                     |   <comment>
                     |   <expr>
                     |   <array_def>
                     |   <enable>
                     |   <disable>
                     |   <asgnmnt>
                     |   <procedure>
                     |   <definition>
                     |   <library>
                     |   <read>
                     |   <write_channel>
                     |   <user_message>
                     |   <loop_condition>
                     |   <if_else_condition>
                     |   <create_channel>
                     |   <close_channel>
                     |   <subroutine_return>
                     |   <begin_state> <statement> <end_state>

expr            ::=      <number>
                     |   <node>
                     |   <comment>
                     |   <asgnmnt>
                     |   <function>
                     |   '(' <expr> ')'
                     |   '[' <expr>
                     |       [{','<expr>}]:1:32 ']'
                     |   <expr> <binop> <expr>
                     |   [ <unop> ] <expr>

alpha           ::=      'A' | . . . | 'Z' | 'a' | . . . | 'z'

digit           ::=      '0' | . . . | '9'

octal           ::=      '0' | . . . | '7'
```

```
hex                  ::=     'a' | 'b' | 'c' | 'd' | 'e' | 'f'
                          |  'A' | 'B' | 'C' | 'D' | 'E' | 'F'

ascii                ::=  ASCII | <ascii>

format               ::=     '%b' | '%d' | '%o'
                          |  '%u' | '%x' | '\n'
                          |  '\t' | '\r' | <format>

comment              ::=     ';' <ascii> EOL

string               ::=     '"' <ascii>:1:512 '"'

format_string        ::=     '"' { <ascii> | <format> }:1:512 '"'

number               ::=     '0x' | <digit> | <hex> }:1:8
                          |  '0' { <octal> }:1:12
                          |  { <digit> }:1:10

identifier           ::=     <digit> | <alpha> | ' ' | '.' | '#'

variable             ::=     {<alpha><identifier>}:1:512

argument             ::=     '$' {<digit>}:1:32767

array                ::=     '[' <expr> ']'

pointer              ::=     @~

address              ::=     '&'

reference            ::=     <pointer> | <address>

node                 ::=     [<reference>] <variable> [<array>]
                          |  [<reference>] <argument> [<array>]

begin_state          ::=     '{' | 'begin'

end_state            ::=     '}' | 'end'

array def            ::=     'array'{   [<pointer>] <variable> '['<expr> ]'
                                      | [<pointer>] <argument> '['<expr>
                                      }

subroutine return    ::=     'return' [ <expr> ]

close channel        ::=     'close' <node>

create channel       ::=     'create' <string> ',' <node>

if else condition    ::=     'if' <expr> [ 'then' ] <statement>
                          |  ( 'if' <expr> [ 'then' ] <statement>
                               'else' <statement>
                             )
                          |  ( 'if' <expr> [ 'then' ] <statement>
                               'else if' <expr> <statement>
                               'else' <statement>
                             )

asgnmnt              ::=     <node> ':=' <expr>

forasgnmnt           ::=     [<reference>] <variable> ':=' <expr>
```

```
up_down           ::=     'to' | 'downto'

for_loop          ::=     'for' <forasgnmnt> <up_down> <node>
                              <statement>

while_loop        ::=     'while' <expr> <statement>

loop_condition    ::      <for loop> <statement>
                       |  <while loop> <statement>

user_message      ::='    message' <format_string> [(',' <expr>)]:0:255

write_channel     ::=     'write' <node> ',' <format_string>
                                   [ ( ',' <expr> ) ]:0:255

read              ::=     'read' '(' <variable> ')'

library           ::=     'load' <string>

definition        ::=     'proc' <variable> '(' ')' <statement>
                       |  'func' <variable> '(' ')' <statement>

procedure         ::=     <variable> '(' [ ( <expr> ',' ) ]:0:32767 ')'

function          ::=     <variable> '(' [ ( <expr> ',' ) ]:0:32767 ')'

unop              ::=     '!'          /* logical negation */
                       |  '-'          /* arithmetic negation */
                          '~'  /* binary ones compliment */

binop             ::=     '^'          /* bitwise exclusive or */
                       |  '|'          /* bitwise or */
                       |  '&'          /* bitwise and */
                       |  '**'         /* exponential */
                       |  '*'          /* multiplication */
                       |  '/'          /* division */
                       |  '+'          /* addition */
                       |  '-'          /* subtraction */
                       |  '%'          /* modulos (remainder) */
                       |  '>'          /* relational greater */
                       |  '>='         /* relational greater equal */
                       |  '<'          /* relational lesser */
                       |  '<='         /* relational lesser equal */
                       |  '>>'         /* bitwise right shift */
                       |  '<<'         /* bitwise left shift */
                       |  '&&'         /* logical and */
                       |  '||'         /* logical or */
                       |  ':='         /* assignment */
                       |  ('=' | '==') /* relational equal */
                       |  '!='         /* relational not equal */
```

Baucus Naur Form Description of Data Structures
Conventions:

::=	definition
' . . . '	literals
< . . . >	nonterminals
[. . .]	optional
(. . .)	grouping

```
{ . . . }        repeat 0 or more times
. . . | . . .    choice (or)
:m:n             repeat m to n times
ASCII            The ASCII character Set
NIL              The empty set
EOL              The end of line marker

machine        ::=   <bcode> <stack> <frame>

bcode          ::=   ( <symbol> | <instruction> |
                       <number> | <bcode> | NIL ) | <bcode>

stack          ::=   ( <datum> | NIL ) | <stack>

frame          ::=   ( <symbol> <instruction>
                       <datum> <number> | NIL ) | <frame>

instruction    ::=   0x00000000 . . . 0xFFFFFFFF

datum          ::=   <symbol> | <real>

real           ::=   1.40129846432817e-45 . . . 3.402823466385288e+38

symbol         ::=   <name> <type>
                     <relatives> <array_size>
                     <index> <kin>
                     ( <real> | <instruction> | <string> )
                     <prev symbol>
                     <next symbol>

number         ::=   0x00000000 . . . . 0xFFFFFFFF

name           ::=   ( 'a' | 'b' . . .'z' | 'A' | 'B' . . . 'Z' |
                     '_' | '-' | '.' | NIL ) <name> | NIL

type           : :=  '+' | '-' | '%' | '/' | '*' | '^' | '>' |
                     '<' | '|' | '&' | '@' | '{' | '}' |
                     128 | 129 | 130 . . . 256

relatives      ::=   0x0000 . . . 0xFFFF

array size     ::=   0x0000 . . . 0xFFFF

index          ::=   ( <symbol> | NIL ) | <index>

kin            ::=   ( <symbol> | NIL ) | <index>

prev symbol    ::=   <symbol> | NIL

next symbol    ::=   <symbol> | NIL
```

LISTING B

```
resetpc (bcode)
while (parser () 'equals' 0) do
        begin
                if (interpret(bcode) 'not equals' 0) then
                        begin
                                return
                        end
                resetpc (bcode)
        end

subroutine parser
        begin
                encode_statement ('statement parsed')
        end

subroutine encode_statement ('statement parsed')
        begin
                opcode := pcode
                pcode := function ('statement parsed')
                pcode :=pcode 'addition' sizeof (pcode)
                return opcode
        end

subroutine function
      begin
            switch on statement
                  case addition                     return (add)
                  case subtraction                  return (sub)
                  case modulos                      return (mod)
                  case division                     return (div)
                  case multiple                     return (mul)
                  case negation                     return (negate)
                  case bitwise exclusive or         return (bxor)
                  case compliment                   return (comp)
                  case greater then                 return (gt)
                  case less than                    return (lt)
                  case bitwise or                   return (bor)
                  case bitwise and                  return (band)
                  case address                      return (rel)
                  case reference                    return (relpush)
                  case logical exclusive or         return (lxor)
                  case logical or                   return (lor)
                  case logical and                  return (land)
                  case not equals                   return (ne)
                  case greater equals               return (ge)
                  case less equals                  return (le)
                  case power                        return (power)
                  case assign                       return (assign)
                  case procedure definition         return (pcode)
                  case function definition          return (pcode)
                  case return                       return (funcret | procret)
                  case if                           return (ifcode)
                  case else                         return (ifcode)
                  case while                        return (whilecode)
                  case arg                          return (arg)
                  case var                          return (varpush
                  case number                       return (constpush)
```

```
case producture execute          return (call | pcall)
case function execute            return (call | pcall)
case built-in function           return (bltin)
case left shift                  return (ls)
case right shift                 return (rs)
case load library                return (pcode)
case exit                        return (progexit)
case equals                      return (eq)
case for                         return (whilecode)
case array                       return (defarray)
subroutine resetpc
        begin
                pcode := bcode
                stackp := stack
                framep := frame
        end

subroutine interpret
        begin
                pc := bcode
                while (pc not 'equals' 0) do
                        begin
                                if ( (*(*pc) ( ) ) 'not equal' 0) then
                                        begin
                                                return
                                        end
                                pc := pc 'addition' sizeof (pc)
                        end
        end

subroutine sizeof
        begin
                return address storage size
        end

subroutine add
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'addition' d2
                push (d1)
        end

subroutine sub
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'subtraction' d2
                push (d1)
        end

subroutine mod
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := remainder of (d1 'division' d2)
                push (d1)
        end

subroutine mul
```

```
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'multiplication' d2
                push (d1)
        end

subroutine div
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'division' d2
                push (d1)
        end

subroutine negate
        begin
                d1 := pop ( )
                d1 := 'negation' d1
                push (d1)
        end

subroutine bxor
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'bitwise exclusive or' d2
                push (d1)
        end

subroutine comp
        begin
                d1 := pop ( )
                d1 := 'ones compliment' d1
                push (d1)
        end

subroutine gt
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'greater than' d2
                push (d1)
        end

subroutine lt
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'less than' d2
                push (d1)
        end

subroutine bor
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'bitwise or' d2
                push (d1)
        end
```

```
subroutine band
        begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'bitwise and' d2
                push (d1)
        end

subroutine rel
        begin
                d := pc
                pc := pc + sizeof (pc)
                if (d isrelated) then
                        begin
                                push (d)
                        end
                else
                        begin
                                return
                        end
        end

subroutine relpush
        begin
                d := pc
                pc := pc + sizeof (pc)
                if (d isrelated) then
                        begin
                                value := 0
                                while (i < relative count of d) do
                                        begin
                                                value := value 'bitwise or'
                                                           relative value 'left shift' i
                                        end
                                d := value
                                push (d)
                        end
                else
                        begin
                                return
                        end
        end

subroutine lxor
        begin
                d2 := pop ( )
                d1 := pop ( )
                if (d1 'equals' unknown 'or' d2 'equals' unknown) then
                        begin
                                d1 := unknown
                        end
                else then
                        begin
                                d1 := d1 'bitwise exclusive or ' d2
                        end
                push (d1)
        end

subroutine lor
```

```
        begin
                d2 := pop ( )
                d1 := pop ( )
                if (d1 'equals' unknown ) then
                        begin
                                if (d2 'equals' unknown) then
                                        begin
                                                push (d1)
                                        end
                                else if (d2 'equals' 1) then
                                        begin
                                                push (d2)
                                        end
                                else then
                                        begin
                                                push (d1)
                                        end
                        end
                else if (d1 'equals' 1) then
                        begin
                                push (d2)
                        end
                else then
                        begin
                                if (d2 'equals' unknown) then
                                        begin
                                                push (d2)
                                        end
                                else if (d2 'equals' 1) then
                                        begin
                                                push (d2)
                                        end
                                else then
                                        begin
                                                push (d1)
                                        end
                        end
        end

subroutine land
        begin
                d2 := pop ( )
                d1 := pop ( )
                if (d1 'equals' unknown ) then
                        begin
                                if (d2 'equals' unknown) then
                                        begin
                                                push (d1)
                                        end
                                else if (d2 'equals' 1) then
                                        begin
                                                push (d1)
                                        end
                                else then
                                        begin
                                                push (d2)
                                        end
                        end
                else if (d1 'equals' 1) then
                        begin
```

```
                        if (d2 'equals' unknown) then
                            begin
                                push (d2)
                            end
                        else if (d2 'equals' 1) then
                            begin
                                push (d1)
                            end
                        else then
                            begin
                                push (d2)
                            end
                    end
                else then
                    begin
                        push (d1)
                    end
            end

        subroutine ne
            begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'not equals' d2
                push (d1)
            end

        subroutine ge
            begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'greater equals' d2
                push (d1)
            end

        subroutine le
            begin
                d2 := pop ( )
                d1 := pop ( )
                d1 := d1 'less equals' d2
                push (d1)
            end

        subroutine power
            begin
                d2 := pop ( )
                d1 := pop ( )
                if (d2 'equals' 0) then
                    begin
                        d1 := 1
                    end
                else then
                    begin
                        for j := 0 and n := 1 to d2 do
                            begin
                                n := n 'multiply' d1
                                j := j 'addition' 1
                            end
                        d1 := n
                    end
```

```
            push (d1)
        end

    subroutine assign
        begin
            d2 := pop ( )
            d1 := pop ( )
            d1 := d1 'assignment' d2
            push (d1)
        end

    subroutine funcret
        begin
            d := pop ( )
            ret ( )
            push (d)
        end

    subroutine procret
        begin
            ret ( )
        end

    subroutine ret
        begin
            for i := 0 to framep argument count do
                begin
                    d := pop ( )
                end
            pc := framep returning pc address
            framep := framep 'subtraction' sizeof (framep)
        end

    subroutine ifcode
        begin
            savepc := pc
            interpret (savepc 'addition' 3)
            d := pop ( )
            if (d) then
                begin
                    interpret (savepc)
                end
            else then
                begin
                    interpret (savepc 'addition' 1)
                end
            pc := savepc 'addition' 2
        end

    subroutine whilecode
        begin
            savepc := pc
            interpret (savepc 'addition' 2)
            d := pop ( )
            while (d) then
                begin
                    interpret (savepc)
                    interpret (savepc 'addition' 2)
                    d := pop ( )
                end
```

```
            pc := savepc 'addition' 1
        end

subroutine arg
        begin
            argument_number := pc
            pc := pc 'addition' sizeof (pc)
            d := framep argument of argument_number
            pushd (d)
        end

subroutine varpush
        begin
            d := pc
            pc := pc 'addition' sizeof (pc)
            pushd (d)
        end

subroutine constpush
        begin
            d := pc
            pc := pc 'addition' sizeof (pc)
            pushd (d)
        end

subroutine call
        begin
            sp := pc
            framep := framep 'addition' sizeof (framep)
            framep symbol of 'equals' sp
            framep number of arguments 'equals' pc 'addition' 1
            framep return address 'equals' pc 'addition' 2
            framep arguments 'equals' stackp 'subtraction' 1
            interpret (sp)
        end

subroutine pcall
        begin
            nargs := pc
            if (nargs 'equals' 0) then begin offset := 1 end
            else then begin offset := nargs 'addition' 1 end
            d := (stackp 'subtraction' offset)
            framep := framep 'addition' sizeof (framep)
            framep symbol of 'equals' d
            framep number of arguments 'equals' pc 'addition' 1
            framep return address 'equals' pc 'addition' 2
            framep arguments 'equals' stackp 'subtraction' 1
            interpret (d)
        end

subroutine bltin
        begin
            d := pop ( )
            d := (*pc (d))
            push (d)
        end

subroutine ls
        begin
            d1 := pop ( )
```

```
            d2 := pop ( )
            d1 := d1 'bitwise left shift' d2
            push (d1)
        end

subroutine rs
        begin
            d1 := pop ( )
            d2 := pop ( )
            d1 := d1 'bitwise right shift' d2
            push (d1)
        end

subroutine progexit
        begin
            return 1
        end

subroutine eq
        begin
            d1 := pop ( )
            d2 := pop ( )
            d1 := d1 'equals' d2
            push (d1)
        end

subroutine defarray
        begin
            d1 := pc
            pc := pc 'addition' sizeof (pc)
            d2 := pop ( )
            d1 := 'define array' 'valueof' d2
        end

subroutine pop
        begin
            stackp := stackp 'subtraction' sizeof (stackp)
            return (pointer (stackp ))
        end

subroutine push
        begin
            stackp := stackp 'addition' sizeof (stackp)
            pointer (stackp ) := d
        end

subroutine pointer
        begin
            return (machine memory address of stackp)
        end
```

CLAIMS

What is claimed is:

1. A programmable interpreter comprising:

means for receiving a command input stream, said command input stream having a command identifier;

means for encoding said command identifier into a corresponding processing component identifier; and

means for executing a processing component identified by said processing component identifier.

2. The programmable interpreter as claimed in Claim 1 further including means for pushing an argument onto a stack, said argument used as an input to said processing component identified by said processing component identifier.

3. The programmable interpreter as claimed in Claim 1 wherein said means for encoding further includes means for generating an execution stream for storage of said processing component identifier and associated arguments.

4. The programmable interpreter as claimed in Claim 1 further including means for popping an argument from a stack, said argument used as an input to said processing component identified by said processing component identifier.

5. The programmable interpreter as claimed in Claim 1 further including means for pushing a result of the execution of said processing component onto a stack.

6. The programmable interpreter as claimed in Claim 3 wherein said means for encoding further includes means for pointing to the first item

associated with said processing component stored in said execution stream.

7. The programmable interpreter as claimed in Claim 3 wherein said means for encoding further includes means for pointing to the first item associated with a second processing component stored in said execution stream.

8. The programmable interpreter as claimed in Claim 1 wherein said means for executing further includes means for recursively executing a processing component.

9. The programmable interpreter as claimed in Claim 3 further including means for interpreting said execution stream.

10. The programmable interpreter as claimed in Claim 3 wherein said execution stream is stored in random access memory.

11. In a programmable interpreter, a process for interpreting a command stream comprising the steps of:

receiving a command input stream, said command input stream having a command identifier;

encoding said command identifier into a corresponding processing component identifier; and

executing a processing component identified by said processing component identifier.

12. The process as claimed in Claim 11 further including the step of pushing an argument onto a stack, said argument used as an input to said processing component identified by said processing component identifier.

13. The process as claimed in Claim 11 wherein said step of encoding further includes a step of generating an execution stream for storing said processing component identifier and associated arguments.

14. The process as claimed in Claim 11 further including a step of popping an argument from a stack, said argument used as an input to said processing component identified by said processing component identifier.

15. The process as claimed in Claim 11 further including a step of pushing a result of the execution of said processing component onto a stack.

16. The process as claimed in Claim 13 wherein said step of encoding further includes a step of pointing to the first item associated with said processing component stored in said execution stream.

17. The process as claimed in Claim 13 wherein said step of encoding further includes a step of pointing to the first item associated with a second processing component stored in said execution stream.

18. The process as claimed in Claim 11 wherein said step of executing further includes a step of recursively executing a processing component.

19. The process as claimed in Claim 13 further including a step of interpreting said execution stream.

20. The process as claimed in Claim 11 further including a step of parsing said command input stream.

ABSTRACT

A programmable interpreter for creating, interpreting, and executing a programming language. The present invention is a virtual processor that eliminates interpretation of pseudo code typical of common interpretive engines. The preferred embodiment of the present invention includes a computer system comprising a bus communicating information, a processor, and a random access memory for storing information and instructions for the processor. The processing logic of the preferred embodiment is operably disposed within the random access memory and executed by the processor of the computer system. A command stream, comprising a command identifier or function name in combination with a string of arguments, is a typical input for the processing logic of the present invention. Upon activation of the processing logic of the present invention, a parser is executed to manipulate the input command stream and produce an execution stream with a processing component identifier corresponding to the specified command. The command is then executed indirectly and a pointer is updated to point to the next command in the execution stream. Arguments for commands are pushed on to and popped from a stack. Results from the execution of commands are pushed onto a stack. For commands that define a new function or procedure, frame data is maintained to preserve the context in which the new function or procedure is executed. Each command in the stream is interpreted in this manner until the end of the execution stream is reached.

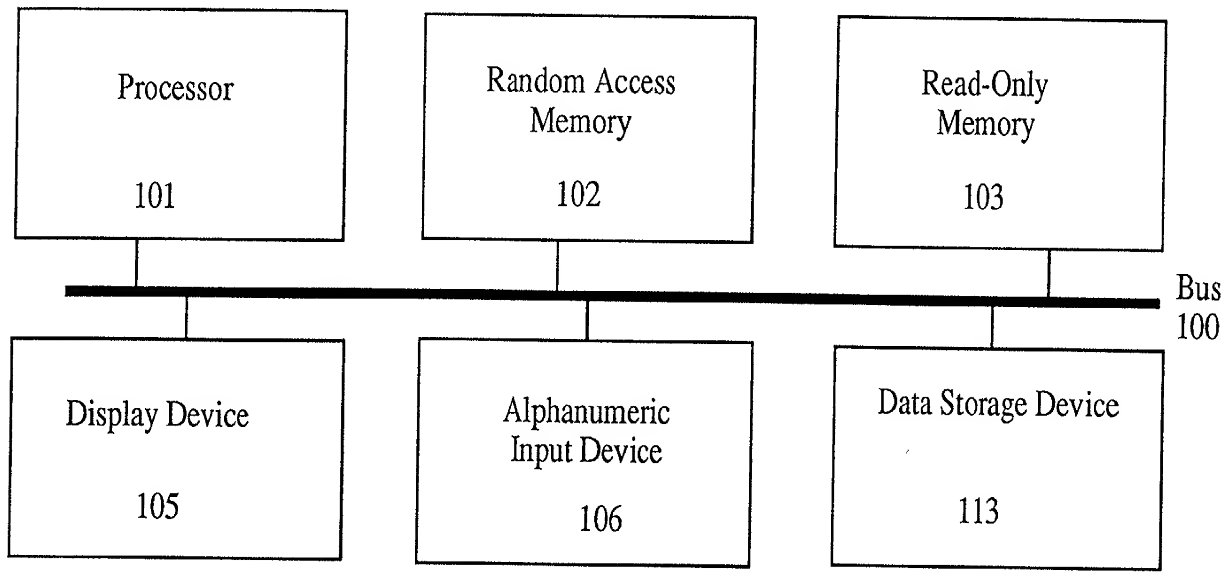

Processor
101
Random Access Memory
102
Read-Only Memory
103
Bus
100
Display Device
105
Alphanumeric Input Device
106
Data Storage Device
113

Figure 1

FIGURE 2a

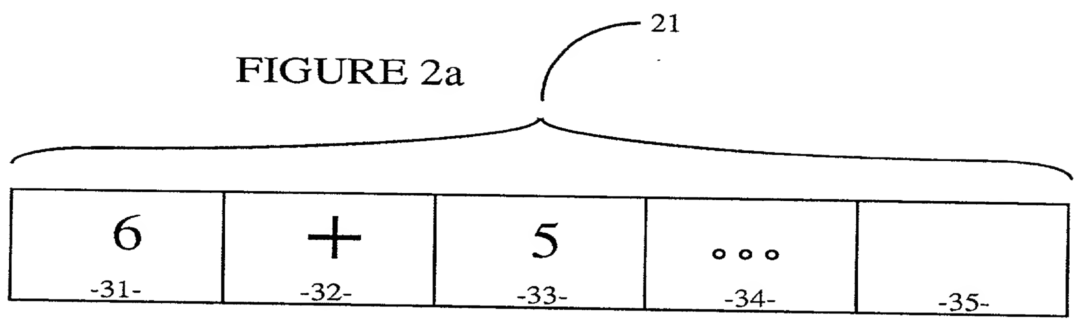


FIGURE 2b

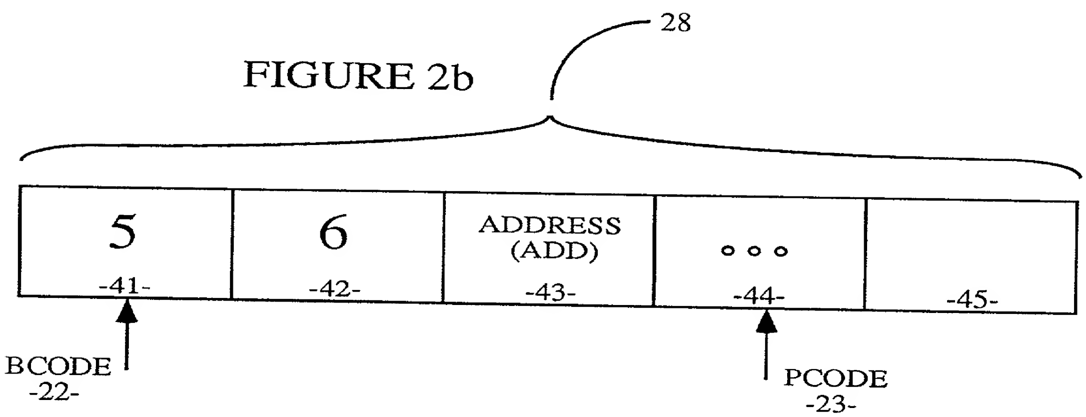


FIGURE 3a

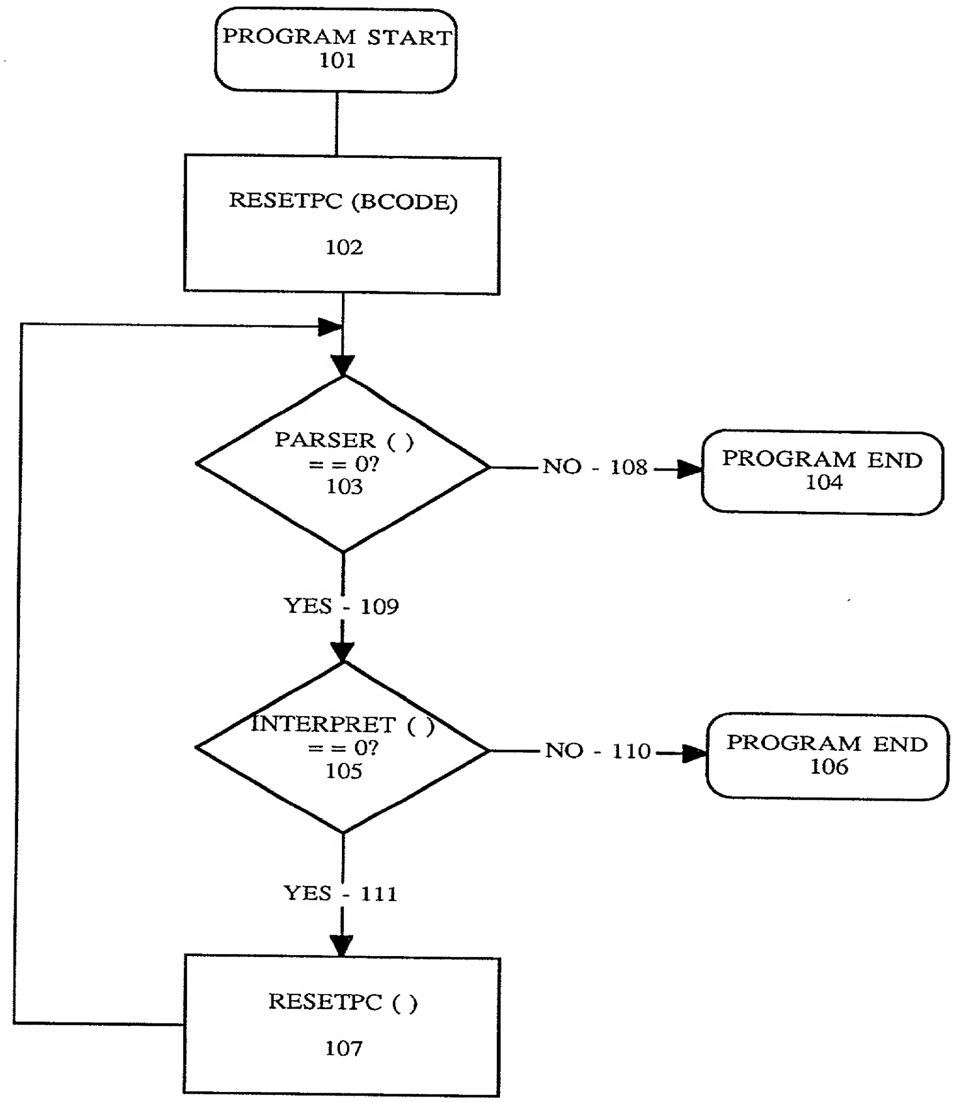

PROGRAM START
101
RESETPC (BCODE)
102
PARSER ( )
= = 0?
103
NO - 108
PROGRAM END
104
YES - 109
INTERPRET ( )
= = 0?
105
NO - 110
PROGRAM END
106
YES - 111
RESETPC ( )
107

FIGURE 3b

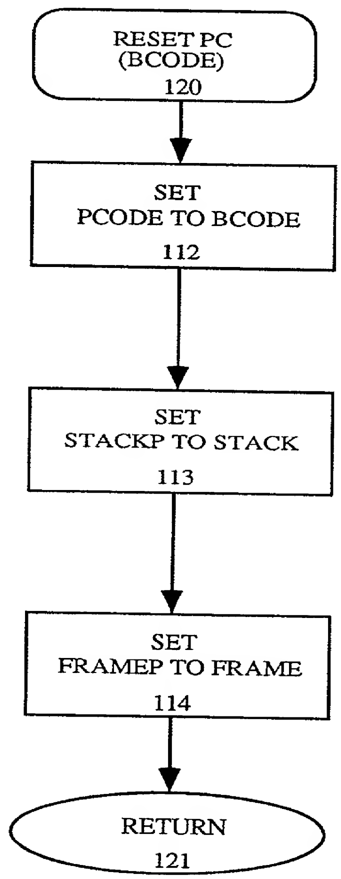

RESET PC
(BCODE)
120
SET
PCODE TO BCODE
112
SET
STACKP TO STACK
113
SET
FRAMEP TO FRAME
114
RETURN
121

FIGURE 4a

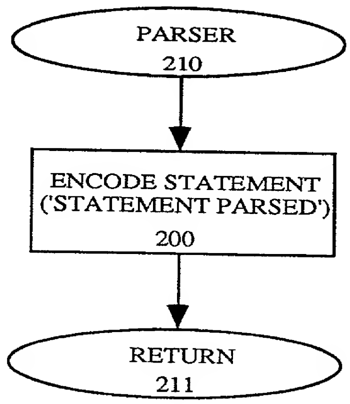


FIGURE 4b

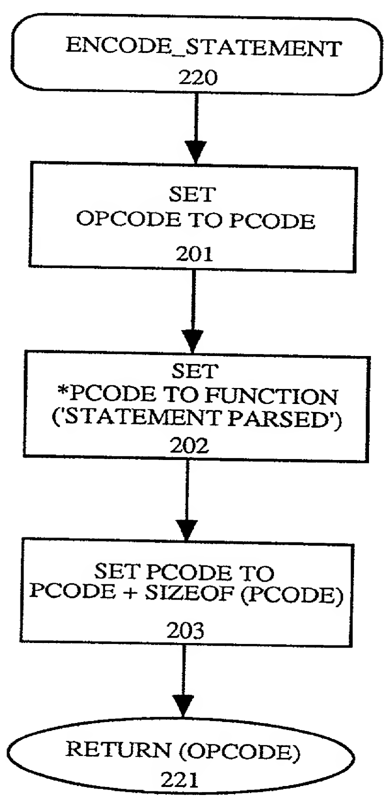


FIGURE 5a

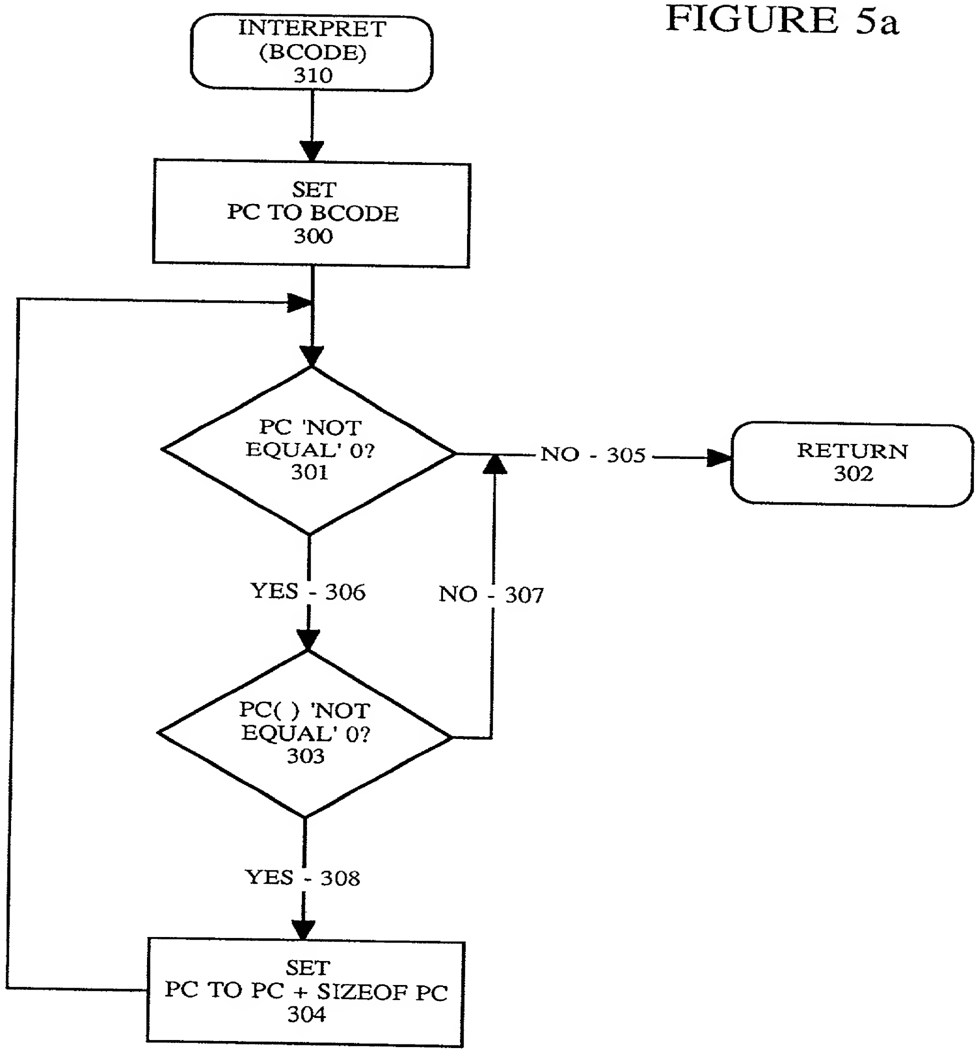
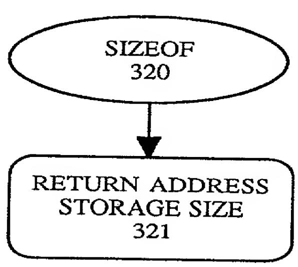


FIGURE 5b



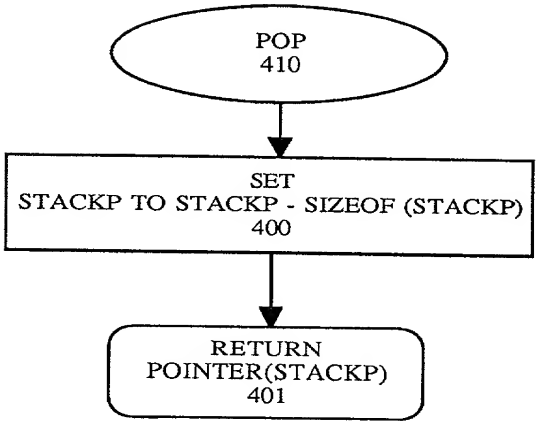


FIGURE 6a

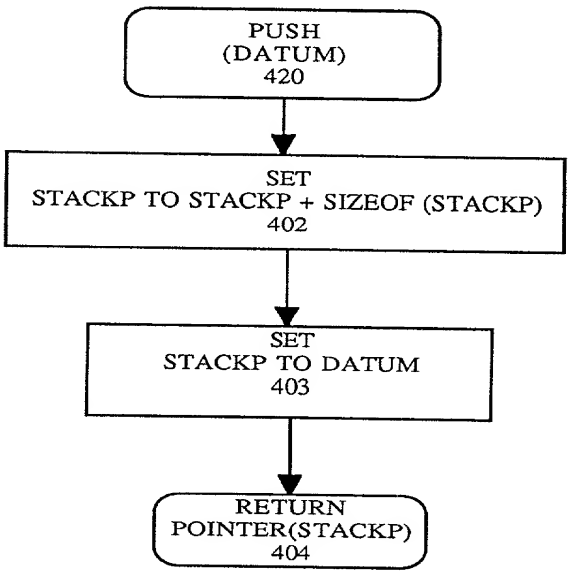


FIGURE 6b

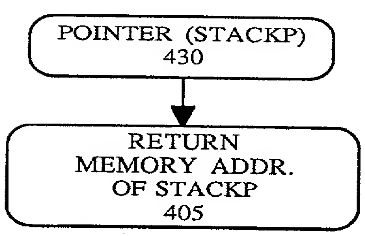


FIGURE 6c

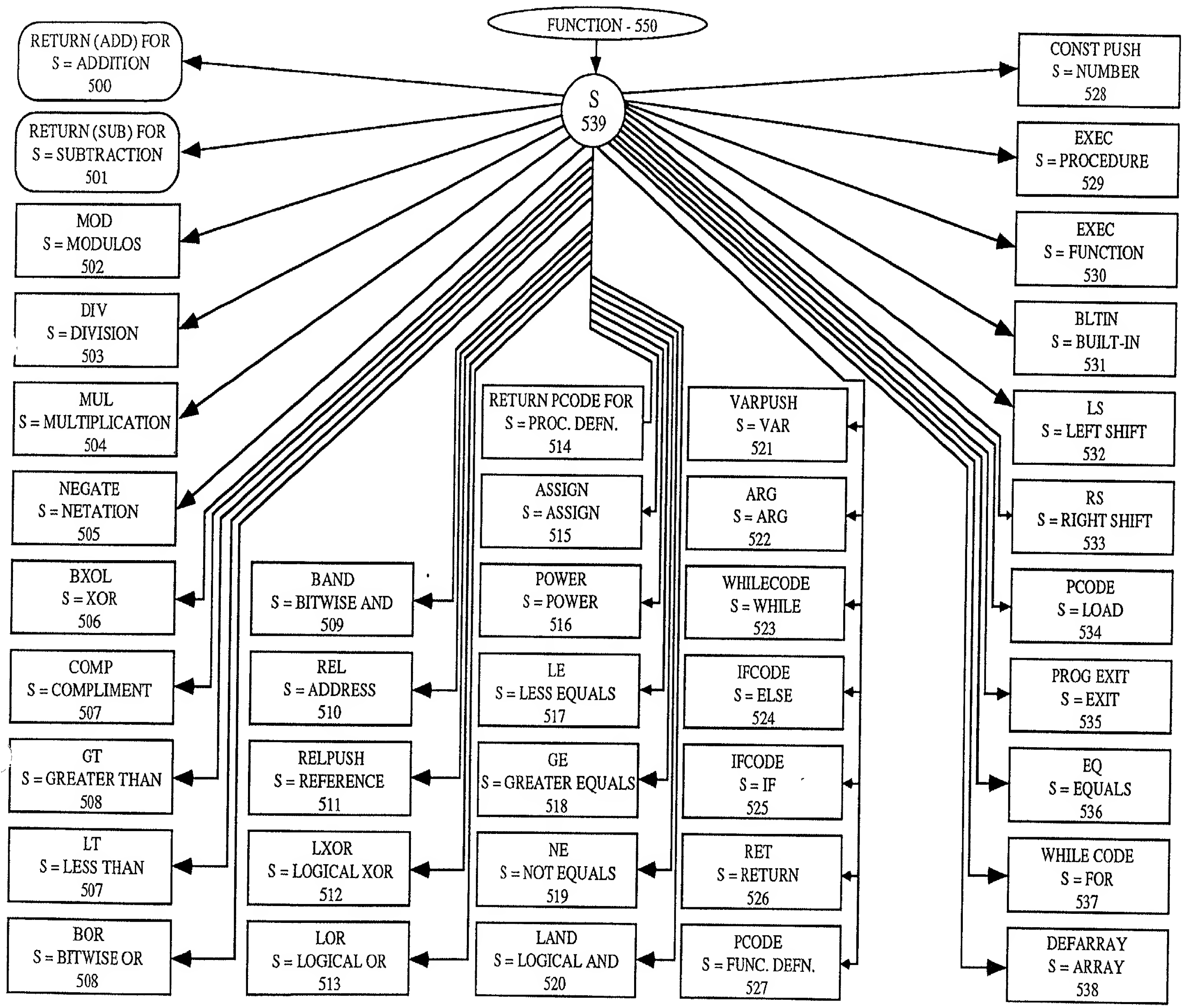


FIGURE 7

09512395 .022400

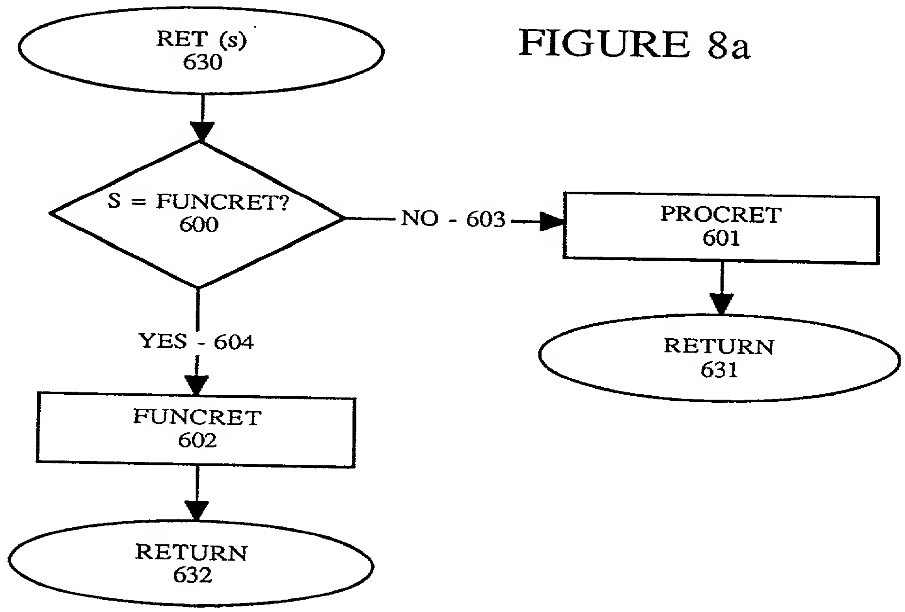


FIGURE 8a

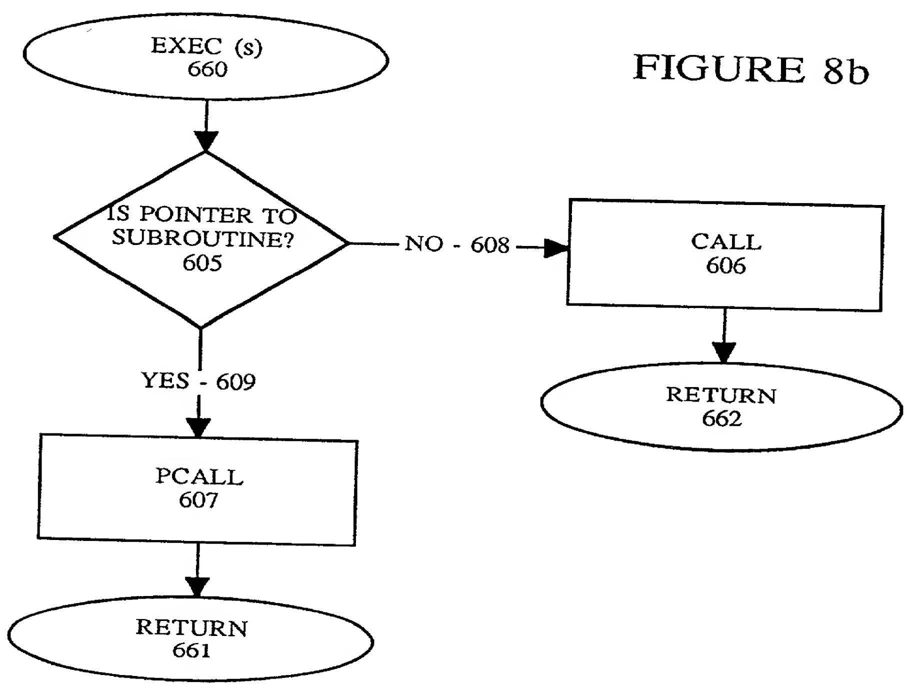


FIGURE 8b

FIGURE 8c

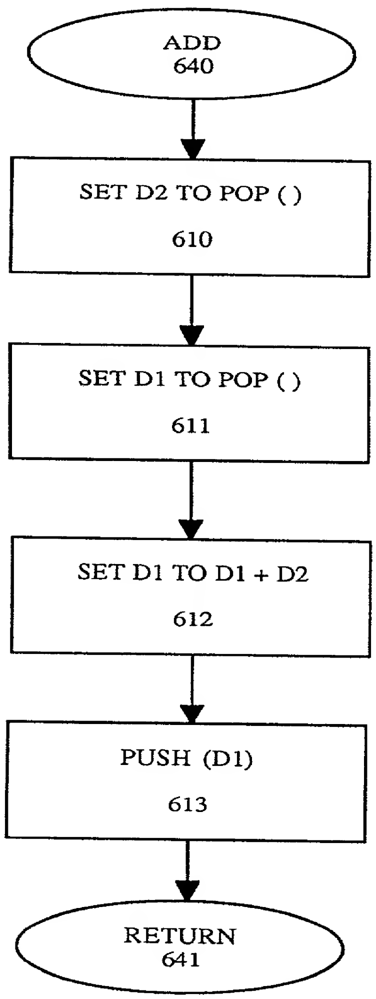
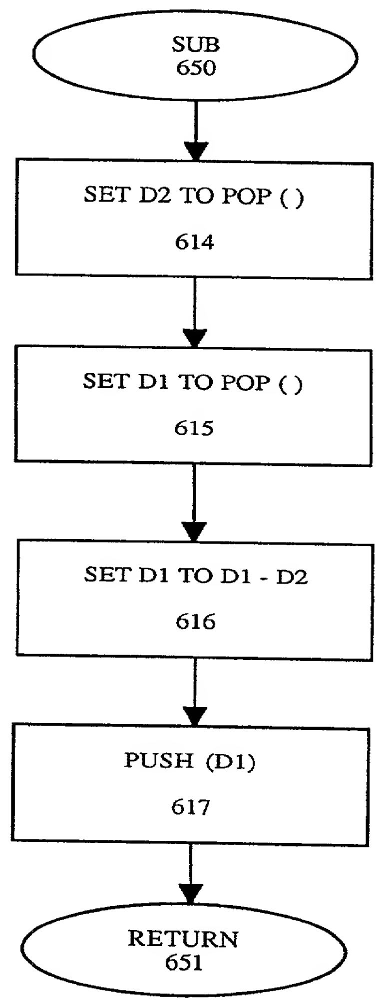


FIGURE 8d



Our Ref.: 42390.P744

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PROGRAMMABLE INTERPRETIVE VIRTUAL MACHINE

the specification of which

XXX is attached hereto.
________ was filed on ________________________ as Application Serial No. ____________________ and was amended on ____________________.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I do not know and do not believe that the same was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119, of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	Filing Date	(Status -- patented, pending, abandoned)
(Application Serial No.)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint Bradley J. Bereznak, Reg. No. 33,474; Roger W. Blakely, Jr., Reg. No. 25,831; Jeffrey Jay Blatt, Reg. No. 30,244; Vernon Randall Gard, Reg. No. 33,886; Stephen D. Gross, Reg. No. 31,020; David R. Halvorson, Reg. No. 33,395; George W. Hoover, Reg. No. 32,992; Michael Hurey, Reg. No. 33,513; Tracy L. Hurt, Reg. No. 34,188; Eric S. Hyman, Reg. No. 30,139; Stephen L. King, Reg. No. 19,180; Maria E. McCormack, Reg. No. 31,639; Ronald W. Reagin, Reg. No. 20,340; James C. Scheller, Reg. No. 31,195; Ira M. Siegel, Reg. No. 28,907; Stanley W. Sokoloff, Reg. No. 25,128; Edwin H. Taylor, Reg. No. 25,129; Lester J. Vincent, Reg. No. 31,460; and Norman Zafman, Reg. No. 26,250; my attorneys; and Keith G. Askoff, Reg. No. 33,828, my patent agent; of BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (213) 207-3800, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature [signature] Date FEBRUARY 28, 1991

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Full Name of Fourth/Joint Inventor ____

Inventor's Signature ____ Date ____

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